Morpholine
Processing

Identification

Chemical Name(s):
Tetrahydro-2*H*-1,4-oxazine

CAS Number:
110-91-8

Other Names:
Tetrahydro-1,4-oxazine; tetrahydro-*p*-oxazine
diethylene oxamide, diethylene imidoxide

Other Codes:
RTECS QD6475000
DOT ID 2054 29
NIOSH Registry Number: QD6475000
UN/ID Number: UN2054

Summary of Advised Recommendation*

Synthetic / Non-Synthetic:	Allowed or Prohibited:	Suggested Annotation:
Synthetic	*Prohibited*	*None.*

Characterization

Composition:
C_4H_9NO

Properties:
Classified as a lower aliphatic secondary amine (Turcotte and Johnson, 1992). A mobile, hygroscopic liquid, with a characteristic amine odor, morpholine is miscible in water with the formation of some heat (Budavari, 1996). Forms a strong base in aqueous solution that is volatile with steam. The mixture of morpholine and water does not have a constant boiling point. Therefore morpholine in aqueous solution is not easily separable by distillation or entraining. Flash point: 100°F. (38°C.). Melting point: -4.9° C. Boiling point at 760mm pressure: 128.9°C. Surface tension at 20°C: 37.5 dynes/cm. Viscosity at 20°C: 2.23cp. (Budavari, 1996).

How Made:
First prepared in 1898 by dehydration of diethanolamine (Budavari, 1996). Also produced by reaction of diethylene glycol and ammonia (Ashford, 1995).

Specific Uses:
The petitioned use is as a boiler chemical. It is also used as a post-harvest fungicide in fruit waxes (Lewis, 1989), a systemic fungicide for field use (Meister, 2000). Other FDA approved uses include as an adhesive; a fungicidal co ating for paper and cardboard; a defoaming agent for pulp and paper; and a corrosion inhibitor for steel and tinplate (See Table 1). Solvent for casein, dyes, resins and waxes (Budavari, 1996). Morpholine has many derivatives including the production of insecticides and herbicides (IPCS, 1996), to produce pharmaceuticals such as anesthetics and antiseptics. It is a rubber accelerator; component of waxes and polishes; optical brightener for detergents; preservative for book paper; organic intermediate; antioxidant (NTP, 2001).

* *This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. This review addresses the requirements of the Organic Foods Production Act to the best of the investigator's ability, and has been reviewed and commented on by experts on the TAP. The substance is evaluated against the criteria found in section 2119(m) of the OFPA (7 USC 6517(m)). The information and advice presented to the NOSB is based on the technical evaluation against that criteria, and is not intended to incorporate commercial availability, socio-economic impact, or any other factor that the NOSB and the USDA may want to consider in making their decisions.*

Table 1 FDA Approved Uses of Morpholine	
Use	**21 CFR**
Food coating (wax)	172.235
Boiler water additive	173.310
Adhesive	175.105
Paper coating	176.180
Defoaming agent (paper)	176.210
Corrosion inhibitor	178.3300
Source: EAFUS, 2001.	

Action:
Neutralizes carbonic acid in steam and steam condensates.

Combinations:
Morpholine is a highly versatile industrial chemical with hundreds of applications and is found in many product combinations. Used as a boiler water additive in conjunction with cyclohexylamine and diethylaminoethanol. Also used in systems with octadecylamine. Used as a preservative in fruit wax. Used as a coating in various waxed cardboard boxes.

Status

OFPA
Equipment cleaner [7 USC 6517(c)(1)(B)(I].

Regulatory

EPA -
Morpholine is on the 1996 Master Test List for the Toxic Substances Control Act. (61 *Fed. Reg*. 65936, 13 Dec 1996; 57 *Fed. Reg*. 61240, 23 Dec 1992). It is also covered under the proposal Report On Volume, Exposure (45 *Fed. Reg.* 13646, 29 Feb 1980). EPA proposed to require manufacturers and processors of morpholine to report production and exposure-related data, which will be used for ranking substances for investigation and for preliminary risk assessments (45 *Fed. Reg.* 13646, 29 Feb. 1980), and was removed from this list in 1982 (47 *Fed Reg*. 38780).

Morpholine is designated a Volatile Organic Compound (VOC) subject to compliance with the emission standards set forth in subpart VV of the Clean Air Act (40 CFR Part 60.489).

Morpholine is an EPA registered pesticide and also appears on EPA Inert Ingredients List 3.

NIEHS - National Toxicology Program Data (2001).

Toxicity
Acute Toxicity: (abbreviations)

dose	mode	specie	amount	unit
LD50	orl	rat	1,050	mg/kg
LC50	ihl	rat	8,000	ppm/8H
LD50	orl	mus	1,200	mg/kg
LC50	ihl	mus	1,320	mg/m3
LD50	ipr	mus	413	mg/kg
LD50	skn	rbt	500	mg/kg
LD50	orl	mam	1,220	mg/kg
LD50	ihl	mam	12,000	mg/m3

AQTX/TLM96: 1000-100 ppm

Sax Toxicity Evaluation:
THR: High via dermal and moderate via oral routes. Irritant to skin, eyes, and mucous membrane.

Carcinogenicity: Not available.

Tumorigenic Data: Not available.

TDLo: orl-mus 2560 mg/kg/Y-C
Review: IARC Cancer Review: Animal Inadequate Evidence
IARC: Not classifiable as a human carcinogen (Group 3)

Mutagenicity: Not available

Teratogenicity: Not available

Other Toxicity Data:
Skin and Eye Irritation Data:
skn-rbt 995 mg/24H SEV
skn-rbt 500 mg open MOD
eye-rbt 2 mg SEV
Review: Toxicology Review
Status: "NIOSH Manual of Analytical Methods" Vol. 3 S150
Reported in EPA TSCA Inventory, 1980
EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule

Hazard Class: 3 Subsidiary Risk: None Packing Group: III

Labels Required: Flammable liquid

Packaging: Passenger: Pkg. Instr.: 309, Y309 Maximum Quantity: 60 L, 10 L
Cargo: Pkg. Instr.: 310 Maximum Quantity: 220 L

Special Provisions: None

Handling Procedures
Acute/Chronic Hazards: This compound is an irritant and is corrosive.

Minimum Protective Clothing: If Tyvek-type disposable protective clothing is not worn during handling of this chemical, wear disposable Tyvek-type sleeves taped to your gloves.

Recommended Glove Materials: Recommended Glove Type For Use With Neat (Undiluted) Chemical: Recommendations based on permeation test results are made for handling the neat (undiluted) chemical. If this chemical makes direct contact with your glove, or if a tear, puncture or hole develops, replace them at once.

Suggested Glove Type(s) (RAD): Butyl rubber, PVA (to 360 minutes)

Recommended Respirator: Where the neat test chemical is weighed and diluted, wear a NIOSH-approved half face respirator equipped with an organic vapor/acid gas cartridge (specific for organic vapors, HCl, acid gas and SO_2) with a dust/mist filter. Splash proof safety goggles should be worn while handling this chemical. Alternatively, a full face respirator, equipped as above, may be used to provide simultaneous eye and respiratory protection.

Storage Precautions: You should store this chemical under refrigerated temperatures, and protect it from moisture. STORE AWAY FROM SOURCES OF IGNITION.

Spills And Leakage: If you should spill this chemical, use absorbent paper to pick up all liquid spill material. Seal the absorbent paper, as well as any of your clothing which may be contaminated, in a vapor-tight plastic bag for eventual disposal. Wash any surfaces you may have contaminated with a soap and water solution. Do not reenter the contaminated area until the Safety Officer (or other responsible person) has verified that the area has been properly cleaned.

Disposal And Waste Treatment: You should dispose of all waste and contaminated materials associated with this chemical as specified by existing local, state and federal regulations concerning hazardous waste disposal. It is suggested that your contaminated materials should be destroyed by incineration in a special, high temperature (>2000 degrees F), chemical incinerator facility.

Skin Contact:
IMMEDIATELY flood affected skin with water while removing and isolating all contaminated clothing. Gently wash all affected skin areas thoroughly with soap and water.
IMMEDIATELY call a hospital or poison control center even if no symptoms (such as redness or irritation) develop.
IMMEDIATELY transport the victim to a hospital for treatment after washing the affected areas.

Inhalation:
IMMEDIATELY leave the contaminated area; take deep breaths of fresh air. If symptoms (such as wheezing, coughing, shortness of breath, or burning in the mouth, throat, or chest) develop, call a physician and be prepared to transport the victim to a hospital. Provide proper respiratory protection to rescuers entering an unknown atmosphere. Whenever possible, Self-Contained Breathing Apparatus (SCBA) should be used; if not available, use a level of protection greater than or equal to that advised under Respirator Recommendation.

Eye Contact:
First check the victim for contact lenses and remove if present. Flush victim's eyes with water or normal saline solution for 20 to 30 minutes while simultaneously calling a hospital or poison control center. Do not put any ointments, oils, or medication in the victim's eyes without specific instructions from a physician.
IMMEDIATELY transport the victim after flushing eyes to a hospital even if no symptoms (such as redness or irritation) develop.

Ingestion:
DO NOT INDUCE VOMITING. Corrosive chemicals will destroy the membranes of the mouth, throat, and esophagus and, in addition, have a high risk of being aspirated into the victim's lungs during vomiting which increases the medical problems. If the victim is conscious and not convulsing, give 1 or 2 glasses of water to dilute the chemical and IMMEDIATELY call a hospital or poison control center.
IMMEDIATELY transport the victim to a hospital.
If the victim is convulsing or unconscious, do not give anything by mouth, ensure that the victim's airway is open and lay the victim on his/her side with the head lower than the body. DO NOT INDUCE VOMITING. Transport the victim IMMEDIATELY to a hospital.

Symptoms: Symptoms of exposure to this compound may include irritation of the eyes, skin, nose, mucous membranes and respiratory tract, nausea, headache, difficult breathing, visual disturbances and coughing.

Other sources –
US Department of Transportation (DOT) Hazardous Materials Table (59 *Fed. Reg.*67395, 29 Dec 1994) [UN2054] [Flammable liquid]

OSHA Permissable Exposure Levels (PEL): 20 ppm, 70 mg/m^3
Skin designation: X (29 CFR 1910.1000).

FDA
Approved by FDA 21CFR 173.310 not to exceed 10 ppm in steam and not approved for contact with milk and milk products.

Status Among U.S. Certifiers

Not allowed by any U.S. Certifier. See the discussion regarding boiler water additives in general in the background paper, Steam Generation in Organic Food Processing Systems (Steam Paper).

International
In a United Nations sponsored review of the environmental and health impacts of morpholine, the United States was the only country mentioned as permitting food additive applications, including application to boiler water. The only other country mentioned in the study was Germany, which forbids the use of morpholine in water-repellent packaging (IPCS, 1996).

Canada – Not included in the list of permitted non-organic additives substances for organic food products (CGSB, 1999).

CODEX- Not in Annex 2, Table 4, 'Processing Aids' (FAO/WHO, 1999).

EU 2092/91 – Not in Annex VI, 'Processing Aids' (EU 2092/91).

IFOAM – Not on Appendix IV, approved processing aids and other products (IFOAM, 2000).

Japan — Not on the list of approved food additives (Woolsey, 2000).

OFPA 2119(m) Criteria

(1) The potential of such substances for detrimental chemical interactions with other materials used in organic farming systems.
As this is a processing material, the substance is not used in organic farming systems. Chemical interactions within a processing environment are discussed in the Steam Paper.

(2) The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.
See processor criteria (3) below.

(3) The probability of environmental contamination during manufacture, use, misuse or disposal of such substance.
This is considered below under item (2).

(4) The effect of the substance on human health.
This is considered in the context of the effect on nutrition (3) below as well as the consideration of GRAS and residues (5) below.

(5) The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock.
Morpholine is not being reviewed for applications where it is released into the agroecosystem, there is no direct effect.

(6) The alternatives to using the substance in terms of practices or other available materials.
See discussion of alternatives in the Steam Paper.

(7) Its compatibility with a system of sustainable agriculture.
This is considered more specifically below in the context of organic handling in (6) below.

Criteria from the February 10, 1999 NOSB Meeting

A PROCESSING AID OR ADJUVANT may be used if;

1. *It cannot be produced from a natural source and has no organic ingredients as substitutes.*
   Morpholine cannot be produced from natural sources and has no organic ingredients as substitutes. When considering chemical means to condition steam lines in boiler systems, the additives to the steam lines must be volatile, so that they purposely travel along with the steam. There are no known non-synthetic boiler additives that can serve this purpose. However, steam can be produced from water without the addition of boiler water additives. A list of substances that are FDA approved for boiler water contact is attached. While these are not direct substitutes, these are available options. The NOSB has already recommended that several of these be listed. See the Steam Paper for more discussion.

2. *Its manufacture, use, and disposal do not have adverse effects on the environment and are done in a manner compatible with organic handling.*
   Produced from ammonia and diethylene glycol. The environmental consequences of the manufacture of ammonia is discussed in the TAP review of ammonium hydroxide. Diethylene glycol is manufactured from ethylene oxide and glycol, a fatty acid alcohol. Ethylene glycol is listed as a hazardous material under EPCRA (40 CFR 355 Appendix A). Production of morpholine requires energy input to drive the synthetic reactions needed to make the material. In the case of synthesis from diethylene glycol and ammonia, energy input is also needed.

   NIOSH and IPCS recommends a variety of protective measures for persons working with this material, including skin and eye protection, and good ventilation (OSHA, 1978; IPCS, 1993) or (by certain manufacturers) respirators (Air Products & Chemicals). Short-term exposure can result in irritation of the skin, lungs, throat, eyes, and nose (OSHA, 1978; IPCS, 1993; Mallinkrodt Baker). Potential hazards of overexposure are visual disturbance, nose irritation, coughing, respiratory irritation, eye and skin irritation, and liver and/or kidney damage (Budavari, Mallinkrodt Baker). It has been shown to cause chronic respiratory disease, liver disease, kidney disease, eye disease (corneal edema), and hypersensitization of the skin (OSHA, 1978). Morpholine is chemically stable in the biosphere, and is not expected to degrade in water environments. Special attention should be given to water organisms (OSHA, 1978; IPCS, 1996).

   Morpholine is flammable and a very dangerous fire hazard when exposed to flame, heat, or oxidizers, and can react with oxidizing materials. Toxic gases and vapors may be released in a fire involving morpholine; when heated to decomposition it emits toxic fumes of nitrogen oxides (Lewis, 1989). The vapor may travel considerable distance to sources of ignition and flash back.

3. *If the nutritional quality of the food is maintained and the material itself or its breakdown products do not have adverse effects on human health as defined by applicable Federal regulations.*
   Morpholine is miscible with water, and forms an azeotrope. Morpholine is rated as very toxic (Gosselin, Smith, and Hodge, 1984). Animals exposed to morpholine showed liver and kidney damage (OSHA, 1978). Morpholine by itself is not considered carcinogenic (NTP, 2001). However, morpholine is a secondary amine known to form nitrosamines (Turcotte and Johnson, 1992). When reacted with nitrates and nitrites, morpholine will form N-nitrosoamines, such as N-nitrosomorpholine (NMOR) (IPCS, 1996). N-nitrosamines are either known or suspected carcinogens, and NMOR is considered a possible human carcinogen by the IARC and an anticipated human carcinogen by the National Toxicology Program (NTP, 2001). Morpholine will also form carbamates under conditions that appear to be antagonistic to forming NMOR (Kirsch, et al., 2000).

4. *Its primary purpose is not as a preservative or used only to recreate/improve flavors, colors, textures, or nutritive value lost during processing except in the latter case as required by law.*
   The primary use is to prevent corrosion of equipment. Because it forms an azeotrope, morpholine will carry over in the steam and will come into direct contact with food exposed to live steam that has been treated with morpholine as an additive. Morpholine is also used as a preservative, primarily with fruit waxes. It is also used in waxed boxes. It is not used to recreate/improve flavors, colors, textures, or nutritive value lost during processing.

5. *Is Generally Recognized as Safe (GRAS) by FDA when used in accordance with Good Manufacturing Practices (GMP), and contains no residues of heavy metals or other contaminants in excess of FDA tolerances.*
Morpholine is not Generally Recognized as Safe (GRAS). The FDA sets a threshold for its use in steam that is in contact with food because of its toxicity. Morpholine is on the FDA Priority-Based Assessment of Food Additives (PAFA) File (CFSAN, 1998).

   Food Chemicals Codex (1996) specifications for Morpholine require the following:

   Assay: Not less than 99.0%
   Distillation range: Between 126.0° and 130.0° C.
   Heavy metals (as Pb): Not more than 1 mg/kg
   Refractive index: Between 1.454 and 1.455 at 20° C.
   Specific gravity: Between 0.994 and 0.997 at 20° C.

6. *Its use is compatible with the principles of organic handling.*
Organic standards are precautionary when evaluating synthetic substances used in food. Volatile amines in general, and morpholine in particular, do not appear to be compatible with the principles of organic handling. They are synthetic, toxic, and are not necessary to produce any food. Given the environmental impacts of the manufacturing process and the adverse health effects from exposure, they do not fit within organic principles. Food processors generated and used steam for a long time without these chemicals. Many organic food processors have already adopted viable and practical ways to address corrosion.

7. *There is no other way to produce a similar product without its use and it is used in the minimum quantity required to achieve the process.*
Culinary steam can be produced without the use of this chemical. See the Steam Paper and reviewers' comments for a further discussion.

TAP Reviewer Discussion*

Reviewer 1 *[Food Science and Nutrition Professor with inspection and certification experience]*
Morpholine is a neutralizing type of boiler additive that is a volatile amine type. Review of the available literature indicates that it is a neutralizing volatile amine type and is a common component of boiler additives used to maintain steam efficiency and reduce corrosion of non-stainless steel steam lines.

Morpholine is a secondary amine, chemically, which has been shown to form N-nitrosomorpholine at physiological pH in a variety of mammalian cells. N-nitrosomorpholine is in a class of powerful carcinogens known as nitrosamines which have been well studied in the literature and whose carcinogenicity is unquestioned. Additionally, morpholine has been shown to cause pulmonary edema, liver necrosis and renal tubular degeneration at vapor levels of concentration. It has also been reported that persons with a history of chronic respiratory, liver, kidney, eye or skin disease may be at increased risk from exposure.

I feel the literature is replete with substantial evidence that morpholine presents a worker safety risk as well as the ability to be converted metabolically in cells to nitrosamines. This is not consistent with the basis of the scientific principles of organic food processing. It is interesting to note that the United States is the only country permitting the use of morpholine in boilers which produce steam for food processing plants in a UN sponsored review. Additionally it is not a GRAS compound as determined by FDA.

Furthermore, no US certifier allows its use. Overall because of its toxicity and potential to be converted *in vivo* to nitrosamines it is not compatible with any system of sustainable agriculture.

* *OMRI's information is enclosed in square brackets in italics. Where a reviewer corrected a technical point (e.g., the word should be "intravenous" rather than "subcutaneous"), these corrections were made in this document and are not listed here in the Reviewer Comments. The rest of the TAP Reviewer's comments are edited for identifying comments, redundant statements, and typographical errors. Any text removed is identified by ellipses [. . .] Statements expressed by reviewers are their own, and do not reflect the opinions of any other individual or organization.*

There are a number of alternatives that processors may consider in lieu of using volatile amines such as morpholine.

A. Install an in-line lock out valve that shuts down the feed line of the boiler additive followed by a purge of the steam line prior to organic processing. This approach may be appropriate for those processing companies who conduct organic processing on an intermittent annual basis.
B. Mechanical deaereation of boiler feed water to remove soluble gasses such as O_2 and Co_2.
C. Pumping boiler feed water through ion exchange systems to remove carbonate and bicarbonate hardness components to reduce the rate and amount of CO_2 and H_2CO_3 generated which may preclude the need for a neutralizing amine.
D. Install stainless steel steam lines which are much more resistant to corrosion.

Therefore exclusion of morpholine should not present any undue hardship for companies certified to produce organic products.

I agree that morpholine is synthetic and should be prohibited from operations where there is direct steam to food contact. I justify this annotation on the basis that if steam is used to indirectly heat food through a heat exchange system then the steam is in a closed loop design and presents minimal risk to the food as well as to plant personnel.

Advised Recommendation to NOSB
1. Synthetic
2. Prohibited
3. Suggested annotation: for processing operations where there is direct steam to food contact.

Reviewer 2 *[Consultant to organic certifiers]*
Morpholine is a synthetic material . . . *[used]* as an additive to steam *[that]* comes into direct contact with organic foods during processing. The function of the morpholine is to neutralize carbonic acid which forms from the steam generation system; neutralization of the acidic condensate stream reduces corrosion of boiler equipment, most notably steam lines.

Morpholine is also used as an ingredient in waxes and polishes and as a component of protective coatings on fresh fruits and vegetables (Winter, 1994). These uses will not be substantively covered in this review, as this is not the petitioners' request, but it could be deduced from the arguments below that these uses do not meet with acceptability under the OFPA and NOSB criteria for organic foods production.

Comments Based on the Criteria
While it is likely that not all processing conditions may result in the formation of carbamates or nitrosamines, it is currently not possible to categorically exclude certain manufacturing processes or product formulations to ensure that these toxic by-products will be avoided.

Historically, NOSB recommendations have been against the contact of any synthetic boiler additives with organic foods. All organic production and processing standards are in agreement that toxic substances should not contaminate organic foods. Organic certifiers in the United States, if they take a position at all on this issue, are consistent in repeating the prohibition recommended by the NOSB.

Live steam can be and is produced in many processing systems without the use of any boiler additives that carry over onto the food products. Boiler water can be treated in advance of use in the system by a variety of methods to soften, deionize, filter, and otherwise purify it. These steps reduce the need for addition of synthetic materials not on the National List to the boiler system. In some applications, the steam or heating system for the food may be changed to one where live steam is not the active agent, but rather heating (of food contents directly, or of steam in contact with food) is done via a heat exchange system. The wide variety and individuality of processing systems which exist is indicative of the many ways in which the full range of processed food products can be made, without the need for toxic boiler additives to be used in contact with organic foods. This reviewer does not know of any food product type that absolutely requires morpholine in steam which contacts organic food.

Justification of use of morpholine by the petitioners is based on the constraints of their particular boiler and steam systems as they currently exist, and on the financial and/or logistical challenges involved with changing those systems so as to avoid contact of the organic food by the morpholine. However, economic considerations are clearly not one of the criteria—either in OFPA or the final NOP rule—for determining the suitability of materials used in organic production systems.

History shows that quite often it has been the case that an organic operator (producer or handler) has had to make substantial changes to their system in order to be compliant with organic standards. These changes often involved redesigning of systems, practices, and techniques. In many cases, such changes resulted in the need for financial investment, as well as an investment in time. Some creativity on the part of the operator was often needed, to devise a new system. This has indeed been the case for certain processors, who made adjustments to their boiler systems or manufacturing practices in order to comply with the prohibition of contact of organic foodstuffs by synthetic boiler chemicals. The inconvenience of having to retool or readjust systems should not be the determining factor in whether or not such materials are added to the National List.

For certain processors, where organic processing events are not frequent, the boiler may be operated without the morpholine for a limited time, without significant affect on the boiler or steam line system. For these operations, no retooling may be needed; instead, a procedure can be designed whereby it is verifiable that the volatile boiler chemical has been exhausted from the system prior to handling the organic goods.

For processors who intend to process frequently enough, or for long enough run times, redesigning of the system will be necessary, in one way or another. Prohibition on the use of volatile boiler chemicals can exist without consigning processors to premature deterioration of their equipment. It is often the case in industry that the creative process involved in redesigning systems has unpredicted benefits (short- and long-term) to the operator and the environment, in terms of long-tern cost-effectiveness and sustainability; efforts in this direction should be encouraged, especially if not doing so results in a compromise of organic principles.

In fact, running boiler equipment designed for use with synthetic additives without the additives in place does lead to deterioration, and consequently lower efficiency of the system, which generally means greater energy consumption (Kohan, 1997). While greater efficiency of energy consumption seems undoubtedly to be desirable (both economically and ecologically), energy balance as a whole has not been considered as factor by the NOSB or certifiers when making determinations on the compatibility or allowability of materials or methods. To use such a factor as a criterion in the case for the volatile boiler additive is therefore inconsistent with the rest of the paradigm, and should not be a determining factor at this time.

Advised Recommendations to the NOSB
Morpholine should be deemed a synthetic, prohibited material, and not be added to the National List for any purpose.

Reviewer 3 *[University staff in Food Science with inspection, consulting, and certification experience]*
Morpholine is petitioned for use as a steam additive chemical to reduce corrosion in pipes. There could be direct food contact in many processing operations when steam is used to cook or heat food, such as in a blancher, cooker, canner, or other operations. Morpholine has no functionality toward the food. Morpholine is rated as very toxic. This would make its use of concern to the organic industry. While morpholine is not rated as carcinogenic, the formation of N-nitrosomorpholine (NMOR) upon reaction with nitrites and nitrates is of serious concern. There is sufficient evidence of potential adverse effects that precautionary action does not warrant allowing its use.

The justification for use of morpholine is no different than trying to justify the use of a synthetic herbicide like Round-Up for organic farming, just because it provides a cheaper alternative to weed control and does not leave any detectable residue. Organic handling isn't about economics or end product testing, it's the process that's critical when evaluating compatibility with organic principles. Food processors generated and used steam for a long time without these chemicals. Many organic food processors have already adopted viable and practical ways to address corrosion without the use of morpholine.

There are other solutions that could be used to produce the desired result (no corrosion of piping). To summarize many of the citations reviewed, 'use of stainless steel piping completely solves the problem of

corrosion.' The justification statement in the petition and the alternative control methods do not mention this as a possible solution. They do mention the costs of capital equipment and provide anecdotal evidence of the life expectancy and replacement needs should boiler water additives not be used, but provide no data to support this. There are numerous tests that can and should be performed periodically to determine the corrosion rates, (even with the use of inhibitors) to insure that equipment is being operated and maintained in a safe and efficient manner. Without confirming studies to show the differences in corrosion rates with and without the use of corrosion inhibitors, it appears that these petitioners are using anecdotal evidence to justify their continued use of cheap toxic chemicals instead of more expensive, but viable alternatives. There are several cited alternatives: stainless steel piping (suitable for all operations); discontinued use during organic processing (some operations); steam to steam heat exchanger (suitable for some operations); secondary boiler for food contact application only (suitable for all operations) that could be used. None of these are necessarily cheap, but all offer a viable alternative to the use of toxic chemicals.

Advised Recommendations to NOSB
Morpholine should not be approved for use as a boiler chemical for organic production.

Conclusion

The reviewers unanimously consider morpholine to be synthetic, and unanimously advise the NOSB to not add morpholine to the National List. Use should remain prohibited in organic handling.

References

See the Steam Paper.